A voice activated apparatus for automatic sequential launching of clay targets for Skeet, Sporting Clays and Trap shotgun sports. The apparatus first detects a voice command and launches target(s) and then detects the gunshot(s) of the shooter to determine the completion of a segment of the shooting sequence and automatically progress to the next segment for activation upon the next voice command. The apparatus comprising a signal processing unit, designed to analyze spectral patterns and signal levels associated with acoustic signals, in order to distinguish the voice command from ambient and gunshot noise and prevent false activation. By tracking the number of gunshots fired by each shooter, the system determines the end of the shooting sequence and controls the number of clay targets allocated to each shooter.
FIG. 2

- Start TO timer
- Reset Sample Counter
- Sample line 12 and Delay DI
- Line 16 = 1
- TO Timer < TO
- Sample counter > ST
- Increase Sample Counter
- Increase shots Counter
- Segment = Doubles
- Update Session Monitor
- Launch Target
- Sample counter > Vt
- Line 12 = 1
- Sample counter > Vt
- YES
- NO
- YES
- NO
- YES
- NO
- YES
- NO
- YES
- NO
- YES
- NO
- YES
- NO
- YES
- NO
- YES
- NO
Stations 1, 2, 6, 7 MAXShots = 4
Stations 3, 4, 5 MAXShots = 2
Station 8 (BH) MAXShots = 1
Station 9 (BL) MAXShots = 1

Start

Station switch transition 1-0

Shots = 0
Options = 0
Read shots LUT

Option switch transition 1-0

Do nothing

Shots > 0 AND OptionFlag=0

Option = 1
OptionFlag=1

MAXShots > shots

Option = 0
OptionFlag=1

Wait for Shooter's input

FIG. 7
AUTOMATIC SHOOTING SEQUENCE CONTROLLER

[0001] This application claims priority to U.S. provisional patent application Ser. No. 61/109,106, filed 28-OCT-2008, the contents of which is herein incorporated by reference.

FIELD OF THE INVENTION

[0002] The present invention relates to a sequence controller for selecting a shooting sequence, automatically controlling the release of targets at each step during a sequence, monitoring a shooter's progress through the sequence and terminating the sequence after completing all steps.

BACKGROUND OF THE INVENTION

[0003] The present invention relates to a system for controlling the launching of "clay pigeon" targets, such as from a Skeet, Sporting Clay or Trap target launchers, by means of detecting the voice command of the shooter and by means for detecting the gunshot sounds that follow the target(s) release. [0004] Traditionally, in shotgun clay shooting sports, clay targets are launched from launching machines. To release a target, the shooter calls the word "pull". The person activating the target launch is called "puller". In response to the word "pull", the puller depresses a switch for launching the appropriate clay targets according to a predetermined sequence. The leader may be self loading and self cocking for release of a target upon receipt of either a mechanical or electrical signal.

[0005] The prior art discloses electrical and mechanical controls connected to the target launcher via cable or via wireless remote control system. Manually operated controls have been used to create a sequence of target opportunities for a shooter in a recreational or competitive environment. Examples of shooting sports where a target launcher is used to present a sequence of target opportunities include Skeet, Sporting Clay, and Trap shooting. In most cases, the shooter issues a command "PULL" to initiate a step in the target launching sequence. The object is to shoot the targets as they are launched resulting in a score reflecting the shooter's performance. One method of launching targets is by a manual hand switch such as that used for Skeet target launchers by a human puller which may be a small box with three mechanical momentary switches configured so that the switch on the upper left corner is for the High house launcher, the upper right switch is for the Low house launcher and the lower center switch is for Doubles (both launchers simultaneously). [0006] Skeet and Sporting Clay employ at least two target launchers operating in sequence that may change for each shooting station. For example in American Skeet, there are 8 stations and two target launchers. One launcher is called "High House" and the other called "Low House". All the shooters on a team take turns on each station. The shooting sequence in American Skeet is shown in table 1:

<table>
<thead>
<tr>
<th>Station number</th>
<th>High house</th>
<th>Low house</th>
<th>Doubles</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 2, 6 &amp; 7</td>
<td>1st &quot;pull&quot;</td>
<td>2nd &quot;pull&quot;</td>
<td>3rd &quot;pull&quot;</td>
</tr>
</tbody>
</table>
tion and shooters are unlikely to accept such adjustment during a competitive shooting session.

SUMMARY OF ONE EMBODIMENT OF THE INVENTION

[0014] The present invention comprises a microphone adjacent to the shooting station to convert sound signals into electric audio signals. The audio signals from the microphone a fed into a signal conditioning stage for amplification and anti-aliasing. The signal from the signal conditioning stage fed into an analyzer to isolate desired audio signals namely, a voice command and a gunshot from ambient noise. The analysis results of the analyzer are fed into a sequence controller which contains a sequence comprising a number of segments chosen by the user. The user selects from a look-up table that may be used by the controller in order to identify the segments of a particular desired sequence. Furthermore, each segment may have a unique pattern of target launchers to be actuated.

[0015] The analyzer provides voice activated target release with high sensitivity to voice and specifically to the spectral pattern found in the vowel /u/ as produced in the word “pull”. The present invention has high immunity to ambient noise and particularly to gunshot noise. The present invention uses a plurality of states in order to analyze desired audio signals. The analyzer monitors audio signals in order to detect the shooter calling for an initiation of the present segment in the desired sequence.

[0016] A target timeout timer is activated upon the issuance of the command to activate the target launcher and has a preset duration associated with the expected period for the target to be available to the shooter. The target timeout timer operates during the period of time when the target is in flight, visible to the shooter and available to be shot. The timer times out at a predetermined time when the target should hit the ground if the target is not shot or be out of shooting range. The analyzer expects gunshots only during the flight time. Detecting the shooter’s gun shot(s) following the “pull” and during the target timeout time is used by the sequence controller to verify that a target was released and shot at and that the next segment of the sequence can be armed for the next target(s) release.

[0017] A means for counting a number of gunshots detected by an audio analyzer is used to track the number of gunshots fired by each shooter, on each station during the shooting season. If the correct number of gunshots are not fired during each segment of a shooting sequence, because of a gun or launcher malfunction the invention automatically reverts to that segment in order to allow the shooter to complete the segment. Furthermore, by tracking the number of gunshots fired by each shooter in each station, the system is able to determine the end of the shooting sequence for each shooter as well as limit the number of targets to the maximum allowed per shooter.

[0018] An operator interface is connected to the sequence controller in order to give a visual indication to the shooter that present shooting segment has been completed. The shooter can also select certain adjustments to the sequence from the operator interface.

[0019] The above description sets forth, rather broadly, a summary of one embodiment of the present invention so that the detailed description that follows may be better understood and contributions of the present invention to the art may be better appreciated. Some of the embodiments of the present invention may not include all of the features or characteristics listed in the above summary. There are, of course, additional features of the invention that will be described below and will form the subject matter of claims. In this respect, before explaining at least one preferred embodiment of the invention in detail, it is to be understood that the invention is not limited in its application to the details of the construction and to the arrangement of the components set forth in the following description or as illustrated in the drawings. The invention is capable of other embodiments and of being practiced and carried out in various ways. Also, it is to be understood that the phraseology and terminology employed herein are for the purpose of description and should not be regarded as limiting.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] FIG. 1A is a Block diagram of a circuit employing hardware analog circuitry and low-end micro-controller to detect and distinguish the incoming audio signals.

[0021] FIGS. 1B, 1C and 1D are detailed schematics illustrating parts of the circuitry of FIG. 1A.

[0022] FIG. 2 is a flow chart diagram illustrating the operation of the system shown in FIG. 1A.

[0023] FIG. 3A is a Block diagram of the a preferred embodiment employing digital signal processing circuitry to detect and distinguish the incoming audio signals.

[0024] FIG. 3B is a detailed schematics illustrating part of the circuitry of FIG. 3A.

[0025] FIG. 4 is a flow chart diagram illustrating the operation of the system shown in FIG. 3A.

[0026] FIGS. 5A-5B are detailed schematic and drawing illustrating the user interface.

[0027] FIG. 6 is a flow chart diagrams illustrating the operation of the sequence controller.

[0028] FIG. 7 is a flow chart diagrams illustrating the operation of the sequence controller.

[0029] FIG. 8 is a Block diagram of another embodiment arranged for an automated “Five-Stand” sporting clays controller.

[0030] Table 1. shows American Skeet shooting sequence in each station.

[0031] Table 2. shows an example of “Five-Stand” sporting clays shooting sequences.

DETAILED DESCRIPTION

[0032] Referring to a shooting sequence controller generally indicated by the numeral 18, comprising an analyzer configured to classify incoming acoustic signals into voice commands and a Shooter’s gunshot distinguished from noise, generally indicated by the number 17. The analyzer 17 detects audio signals at microphone 1 isolates audio commands by band pass filter 3, voice peak detector 6 and first comparator 10 to provide a signal for analysis with ambient noise signal on noise line 9 at second comparator 11 to identify a voice command from among an ambient noise and send a voice command signal on line 12 to an input on controller 20. Likewise, audio signals are passed on line 13 to high pass filter 4 (HPF 4) and noise peak detector 7 for identification of ambient noise for comparison to audio commands at second comparator 11 to eliminate false detections.

[0033] Continuing to refer to FIG. 1A, the incoming audio signals are picked up by a microphone 1 and amplified by amplifier 2. Amplifier 2 is typically an operational amplifier arranged in non-inverting configuration with a gain between
100 to 200 (40-46 dB). Amplified audio signal 13 from amplifier 2 is fed in parallel into two active filter blocks band pass filter 3 and high pass filter 4.

[0034] Continuing to refer to FIG. 1A, band pass filter 3 (BPF 3) may have a low frequency cutoff typically at 400 Hz and a high frequency cutoff typically at 800 Hz. This band covers the spectral range of the first formant of the vowel /a/ as in the word “pull” for most male and female talkers. The second formant having significantly less energy is present in the range 900 to 1400 Hz. BPF 3 is typically configured of two second order multiple feedback band pass (MFBB) filters with Q factors between 2 and 3. The first MFBB having a center frequency of approximately 500 Hz and the second MFBB having a center frequency of approximately 700 Hz. The output of BPF 3 and voice peak detector 8 is termed hereafter the “voice” channel.

[0035] Continuing to refer to FIG. 1A, high pass filter 4 is a second order high pass filter (HPF 4) with a cutoff frequency typically at 2400 Hz. This filter attenuates the level of the first formant of the vowel /a/ as in the word “pull” by more than 10 times and the second formant of this vowel by an average of 4 times. To achieve a more precipitous slope, HPF 4 typically configured as two poles Sallen-Key Chebyshev filter with a ripple of 1-2 dB. The output of HPF 4 and noise peak detector 7 is termed hereafter the “noise” channel.

[0036] Continuing to refer to FIG. 1A, the signals from the “voice” channel (outputs of BPF 3) and “noise” channel (output of HPF 4) during the production of voice and particularly the vowel /a/ in the word “pull” and during the noise from a gunshot. When the vowel /a/ in the word “pull” is present, the signal level of the “voice” channel will be significantly higher than the “noise” channel (typically by a factor of 10). The noise from a gunshot has a very high crest factor and therefore after approximately 10 mS from the actual shot, the noise is spread rather evenly across the spectrum up to approximately 10 KHz. While BPF 3 only passes a small portion of the energy from the gunshot noise in its restricted bandwidth, HPF 4 has a much greater bandwidth and thus passes more energy from the gunshot noise.

[0037] Referring to FIG. 1A, DC signals 8 and 9 from respective voice peak detector 6 and noise peak detector 7 corresponding “voice” channel and a “noise” channel are fed into first comparator 10 and second comparator 11. First comparator 10 detects when the voice signal from peak detector 6 is above a preset threshold. Second comparator 11 detects when the level of voice signal from peak detector 6 is greater than noise signal from peak detector 7. When both conditions are simultaneously detected, output signal 12 of second comparator 11 is set to logic high. A detailed description of first comparator 10 and second comparator 11 is provided with reference to FIG. 1C.

[0038] Continuing to refer to FIG. 1A and referring to FIG. 1B, the signals 8, 9 from BPF 3 and HPF 4 are respectively fed into two identical precision AC peak detectors voice peak detector 6 and noise peak detector 7 each producing DC voltage proportional to the positive peak of the AC signals from the respective BPF 3 or HPF 4. Voice peak detector 6, which is also identical to noise peak detector 7 may comprise a third comparator 31 (such as an LM393 or LM339) arranged in non-inverting mode and a switching diode 32 are used to precisely track the positive peak of the input AC signal 5 via feedback to the inverting input. An RC circuit 33 comprising a resistor (typically 10K) and a capacitor (typically 1 uF) removes the AC ripple from output signal 8 while maintaining fast response to changes in the positive peak level of input signal 5.

[0039] Referring to FIG. 1C and continuing to refer to FIG. 1, the schematic of comparator block 10. The “voice” channel from peak detector 6 may be fed into block 10 comprising a comparator 36 (such as in LM393 or LM339) arranged in non-inverting configuration. Potentiometer 37 determines the sensitivity threshold by setting the reference level on the inverting input of comparator 36. During low level acoustic noise, the signal from peak detector 6 is below the reference level and the output of comparator 36 is logic low (i.e., zero). When the shooter’s voice is loud enough, the signal level in the voice channel is above the reference level the output of comparator 36 is logic high (i.e., 1). Likewise block 11 may comprise a comparator 38 and LM393 or LM339 configured to distinguish between voice and noise on a relative basis. The “voice” channel from peak detector 6 is also fed into the non-inverting input of comparator 38 and the “noise” channel from peak detector 7 is fed into the inverting input of comparator 38. When the shooter calls “pull” the signal level in the voice channel is greater than the level in the “noise” channel on line 9 and comparator 38 operates as a non-inverting configuration. If during that time, the shooter’s voice is loud enough to cause the voice channel to generate a signal on line 8 that crosses the sensitivity threshold set by potentiometer 37, comparator 36 produces logic high which in turn pulls up the output of comparator 38 setting control signal 12 to logic high. During loud ambient noise or gunshots noise, the signal level in the “voice” channel may be greater than the level in the “voice” channel and the output of comparator 38 is pulled low (to ground) overriding the output of comparator 36 such that control signal 12 is in logic low state. Thus is should be apparent that comparators 36 and 38 are arranged in a logic “AND” configuration so that only when the shooter voice contains the spectral energy distribution such as in the /a/ in the word “pull” and the loudness of the voice is above a preset sensitivity threshold, a voice command is detected. The arrangement of comparators 6, 7, 10 and 11 may be implemented with a single device comprising four comparators such as National Semiconductors LM339 Quad Comparator.

[0040] Continuing to refer to FIG. 1A, and referring to FIGS. 1D and 2, when a voice command is detected, second comparator 11 produces a logic high level on control signal 12 indicating a voice command has been detected. Control signal 12 is fed into a general purpose input of a low cost Micro-Controller (MCU) 20. MCU 20 may be set to periodically sample the state of line 12 or to start periodic sampling only upon interrupt on transition from low to high state of line 12. Upon detecting a transition from a low to a high state on line 12, MCU 20 resets a Sample Counter 51. Block 52-54 operate in a loop having a preset number of repetitions represented by a constant Vt, (typically a value between 4 and 10). Block 52 samples the state of line 12 and then introduces an interval delay Dt (typically 5 mS). During each cycle of the loop block 53 evaluates the state of line 12. If any of the samples fails to detect a state of 1 (logic high on line 12), the loop is aborted, the Sample Counter is reset and the loop starts over. Each time line 12 is sampled with a value of 1, block 55 increases the value of a Sample Counter by 1. Block 54 exits the loop when the value of the Sample Counter is greater than Vt. By counting Vt consecutive samples, the loop ensures that a voice is detected steadily for a period of 20-50 mS to determine that a valid voice command is present. Once such a valid
voice command has been detected at line 12, block 56 signals to the sequence controller block in MCU 20 to sends a signal on bus 24 which activates the appropriate target launcher 19 and then progress to the next segment of the sequence (FIG. 6).

[0041] Referring to FIG. 1A and FIG. 1D, shot peak detector 14 and shot comparator 15 provide detection of the shooter's own gunshot in order to automatically determine if the current shooting segment has been completed. Shot peak detector 14 and shot comparator 15 may receive audio signal 13 from amplifier 2 into shot peak detector 14 comprising a half wave voltage doubler formed by switching diodes 41 and 42 and respective capacitors. Due to its non-linear characteristics, shot peak detector 14 produces very low level DC output for low level input AC signal and sharp DC output level when the input AC signal is above the diodes threshold (approximately 600 mV). Thus the circuit of shot peak detector 14 will produce very low DC levels for voice, ambient noise or gunshots from other fields. Shot peak detector 14 will produce significantly higher DC levels for gunshot noise from the shooter’s own gun which is relatively close to the microphone producing high sound pressure levels in excess of 100 DBSPL. The output of shot peak detector 14 is termed hereafter the “shot” channel. The DC signal from shot peak detector 14 is fed into shot comparator 15 comprising a non-inverting input of comparator 45. Potentiometer 44 connected to the inverting input of comparator 45 sets a reference level termed the “shot threshold.” Upon a gunshot from the shooter's gun, the DC level from shot peak detector 14 exceeds the threshold and output of comparator 45 on signal 16, is set to logic high. For lower level ambient noise the state of signal 16 is logic low.

[0042] Continuing to refer to FIG. 2, block 56 releases a target and engages the means for detecting a gunshot. The target release resets the Sample Counter at block 51, starts a time-out timer at block 58 and starts a loop, blocks 59-63, having a preset number of repetitions St, (a value between 3 and 6) to determine if a gunshot followed the release of the target. Block 59 samples the state of signal 16 followed by interval delay Dt (typically 5 mS). During each cycle of the loop the state of line 16 is evaluated in block 61. If any of the samples fails to detect a state of 1 (logic high) at line 16, the loop is aborted, the Sample Counter is reset (block 51) and the loop starts over. Also, as shown in block 62, during each cycle of the loop, the value of the time-out period is compared with a preset time period TO. The time out period TO represents the time it takes the clay target to hit the ground or go out of shooting range. If the timer value exceeds the timer interval, the loop is aborted, block 68 controls the sequence controller causing it to revert to the previous segment and the process starts over from block 50. If a shot is not detected within the time-out period, MCU 20 does not progress to the next segment and the next time the shooter calls “pull” will release a target from the same target launcher(s) 19 again. As shown in block 61, while the value of the time-out timer is smaller than the time-out period, each time line 16 is sampled with a value of 1, block 55 increases the value of the Sample Counter by 1. Block 63 exits the loop when the value of the Sample Counter is greater than St. By counting St consecutive samples, the loop ensures that a very loud sound, corresponding with a gunshot from the shooter’s own gun, has been steadily detected for a period of 15-30 mS. Next, the means for counting shots is used to determine if the current segment should terminate. The shots counter in block 64 is increased by 1. If the current segment activates only one target launcher with a single target, requiring a single shot, decision block 65 results in false (no) and block 66 resets the shot counter and time-out timer and means for terminating the current segment terminates the current segment. The means for incrementing the index increments the index to advance the controller to the next segment and the process starts over from block 50 waiting to execute the next segment of the sequence upon the shooter’s next “pull”.

[0043] Continuing to refer to FIG. 2, if the current segment is “doubles”, activating two target launchers 19 (FIG. 1A) to launch two targets, which requires two shots, decision block 65 results in true (yes) and the system goes to block 67 to check if a second shot was fired. If the means for detecting a gunshot did not detect a second shot then the controller assumes a second shot has been not fired and the Sample counter is reset (51) and the system returns to block 59 to repeat the process and wait for a second shot. If a second shot is detected within the time-out period, the means for terminating the segment terminates the current by going to block 66 and starting over from block 50. Otherwise, if a second shot is not detected and the time out timer elapsed, the loop is aborted, block 68 controls the sequence controller causing it to revert to the previous segment and the process starts over from block 50 without progressing to the next segment of the sequence. If the means for detecting shots does not detect the correct number of gunshots for the current segment, the means for repeating the current segment reverts to waiting for a voice command and indicates to the shooter by the operator interface, that the segment will be repeated.

[0044] Referring to FIG. 3A, a second embodiment may comprise detecting incoming acoustic signals at microphone 1 and transmitting audio signals on line 71. Signals on line 71 may be fed into signal conditioning means 117. Signal conditioning means may comprise programmable gain amplifier (PGA) 80 at anti-aliasing filter 74 for providing a signal at line 75 for input into MCU 70. The amplified audio signal at line 75 may be biased to 1/2 the DC supply voltage, and fed into anti-aliasing filter 74 without any decoupling. Filter 74 comprises an active low pass filter (LPF) which may be configured as a third or fourth order Sallen-Key Butterworth filter having a cutoff frequency at approximately 3 KHz. The output of LPF 74 is fed directly into an analog input of MCU 70 comprising an 8 bit or 10 bit ADC. MCU 70 is set to sample the audio signal at a sampling rate Fs which is twice the required audio bandwidth. PGA 80 may have two gain values that may be controlled by MCU 70 via line 76. Micro-controller 70 may be a low cost 8 bit micro-controller (such as a Micro-Chip PIC18 series) also comprising a built-in 8 bit or 10 bit Analog to digital converter (ADC). The output from PGA 80 to said ADC is fed via anti-aliasing low pass filter (LPF) 74.

[0045] Continuing to refer to FIGS. 3A and 3B, one embodiment of a programmable gain and frequency response amplifier such as PGA 80 may be designed to increase the dynamic range of the system when using a low resolution ADC (i.e., 8 or 10 bit) and prevent signal saturation during very loud sounds such as a gunshot. The circuit of PGA 80 comprises an operational amplifier 81 (such as Texas Instruments TL072) arranged in single supply non-inverting configuration. A resistor network provides 1/2 VCC DC bias to the non-inverting input which will be present on the output and used to set the middle of the conversion scale of the ADC. Transistor 86 is a switching transistor (such as 2N7002 small signal N-channel MOSFET). The gate of transistor 86 is
controlled by line 76 from MCU 70. When line 76 is low, transistor 86 is off and the AC signal gain of amplifier 81 is a function of the ratio between the feedback resistor 82 and resistor 83. When line 76 is high, transistor 86 is on, having insignificant resistance, and the AC signal gain of amplifier 81 is a function of the ratio between the feedback resistor 82 and the resistance of parallel resistors 83 and 85. Since the resistance of parallel resistors 83 and 85 is significantly lower than the resistance of resistor 83, when line 76 is set high, the gain is significantly higher.

Continuing to refer to FIGS. 3A and 3B, the values of resistors 82, 83 and 85 are selected to provide a low gain of approximately 28 dB (a factor of 25) and a high gain of approximately 40 dB (a gain factor 100). The high gain mode is used during detection of voice. The low gain mode is used during the detection of a shot to prevent signal saturation. The values of capacitors 84 and 87 can be selected to perform a different first order high pass filter cutoff frequency for each gain mode. Typically, in low gain mode, resistor 83 and capacitor 84 are selected to provide a cutoff frequency of 400 Hz and in high gain mode the parallel resistors and capacitor network form a cutoff frequency at approximately 100 Hz. Other methods for implementing similar programmable gain and frequency response amplifiers may also be implemented with similar results.

Continuing to refer to FIGS. 3A and 4, Fs may be set at 6.4 KHz providing audio bandwidth of up to 3.2 KHz and a sampling period Ts of 156 ps. To derive a “Voice” channel and a “Shot” channel, MCU 70 performs a simplified and computationally efficient version of the Discrete Fourier Transform (DFT) algorithm known as 1-bit DFT. This algorithm is known to a person skilled in the art and has been described in details in professional literature (see Microchip application note AN257). The 1-bit DFT algorithm is independent of signal intensity and requires only zero crossing (polarity) of the signal. A square wave comprising only the most significant bit (MSB) of the ADC result, carrying the polarity information of the digital audio data stream, will be compared to two reference square wave signals derived for each band (k) from the cosine and sine of each respective data point (n points/samples). Said reference signals can be stored in pre-calculated lookup tables. The result of the comparison is 1 for match and -1 for mismatch. The results are accumulated in counters. After calculating n samples, the absolute value of the sum of the counters is directly correlated with the energy in the calculated band (k bands). Preferably, in order to produce relatively wide bands, the number of samples (n) per each analysis frame should be small. At the preferred sampling rate, a value of n=32 will yield 16 bands (k bands) of 200 Hz each covering the audio bandwidth of 3.2 KHz. For the “Voice” channel, bands numbers 2, 3 and 4 are summed to form a wider band in the range 300 Hz-900 Hz. For the “shot” channel bands 8, 9, 10, 11 and 12 are summed to form a wider band in the range 1.5 KHz-2.4 KHz. Thus only a total of 8 bands may be computed. Due to the simplicity of this algorithm, the result in each band represents only the relative spectral distribution of energy not an absolute value. Each 1-bit DFT analysis frame comprises n digital audio samples. To obtain an absolute measurement of the signal level, a moving average of the peak values is calculated for the n samples in each frame. The average peak value Pavg is highly correlated with the band(s) having the highest relative energy level. Thus as the end of each frame the system provides a number Pavg corresponding with said average peak value, a value Vband corresponding with the sum of relative energies in the voice channel’s bands and a value Sband corresponding with the sum of relative energies in the Shot channel’s bands. The duration of each analysis frame Wt is: Wt=1/Fs/n. For example, if Fs=6400 Hz and n=32, the duration of each analysis frame is approximately 5 mS (sampling period 156 µSx32 samples=4.99 mS).

Continuing to refer to FIG. 4 the analysis and decision process performed by MCU 70 may start in block 90 by setting the analysis type variable “WaitVoice=”1”, and setting line 76 to logic high (1). When line 76 is in high state, PGA 80 is in high gain mode sensitive enough to detect voice. A frame counter is reset to zero in block 91. Data acquisition n samples from the ADC is performed in a loop of n repetitions controlled from block 92 which performs the signal processing algorithm. Once the results of the frame are computed, block 92 produces the resulting values Pavg, Vband and Sband described earlier. Since the current analysis type is WaitVoice=1, decision block 93 result is true (yes). Decision block 94 checks if the average peak Pavg is above the voice sensitivity threshold Vth. If Pavg is smaller than Vth, the process starts over and the Frame counter is reset in block 91. If Pavg is greater than Vth, decision block 95 checks if the spectral distribution matches the sound “/u/” in the word “pull”. If the voice band Vband is not greater than the shot band Sband plus a margin constant Vt (typically an integer having a value between 2*n/3 and n), the process starts over and the Frame counter is reset. Otherwise, if Vband is greater than Sband plus Vt, block 96 increases the frame counter by 1. Decision block 97 checks if the frame counter surpassed the constant Vt. (typically a value between 4 and 10). If the loop comprising data acquisition, signal processing and decision blocks 94, 95 and 97 is repeated until the frame counter is greater than Vt. When the result of block 97 is true, a voice has been steadily detected for a period of Vt*Wt (for Wt=5 mS and Vt=7, the period is 35 ms) ensuring that valid voice command is present. Once a valid voice command has been detected, block 56 signals the sequence controller block in MCU 70 to activate the appropriate target launcher(s) by sending signal on bus 24 and then progress to the next segment of the sequence.

Continuing to refer to FIG. 4, following the target release, block 99 the means for detecting a gun shot is monitored, the target release command may prepare the analyzer for shot analysis. The analysis type variable is set to “WaitVoice=0”. Line 76 is low (0) to reduce the gain of PGA 80 by approximately 12 dB. A shots counter variable is cleared to 0. A time out timer is reset to zero and started. The frame counter is reset to zero in block 91. These settings are followed by other data acquisition and signal processing frame in block 92. Now that WaitVoice=0, decision block 93 results in false (no). Decision block 100 checks if the Average Peak, Pavg, is above the Shot sensitivity threshold Sth. If Pavg is smaller than Sth, the process starts over and the frame counter is reset (block 91). If Pavg is greater than Sth, decision block 101 checks if the spectral distribution matches a gunshot. If the Shot band Sband is not greater than the voice band Vband plus a margin constant Sf, the process starts over and the frame counter is reset. Otherwise, if Sband is greater than Vband plus Sf, block 96 increases the frame counter by 1. Also, as shown in block 103, during each cycle of the shot detection loop, the value of the time-out timer is compared with a preset time period TO. The time out period TO is usually the time it takes the clay target to hit the ground or go out of shooting.
range. If the timer value exceeds the time-out period, the loop is aborted, block 68 signals the sequence controller to revert to the previous segment and the process starts over from block 90. Thus, if a shot is not detected within the time-out period, MCU 70 does not progress to the next segment and the next time the shooter calls “pull” will release the same target launcher(s) again. While the time-out timer is smaller than TO, decision block 104 checks if the frame counter surpassed the constant S (previously a value between 2 and 4). The loop comprising data acquisition, signal processing and decision blocks is repeated until the frame counter is greater than S. Thus, when the result of block 104 is true, a very loud sound has been steadily detected during ST frame periods for a total period of 10-20 mS, ensuring the presence of a gunshot from the shooter’s own gun. Now block 105 increases the shots counter by 1. If the current segment activates only one target launcher, requiring a single shot, decision block 106 results in false (no) and the system goes to block 109 to check if a second shot was fired. If a second shot has not been fired the frame counter is reset in block 91 and the system returns to block 92 to repeat the process and wait for a second shot. If a second shot is detected within the time-out period, and the process starts over from block 90, waiting to execute the next segment of the sequence upon the shooter’s next “pull”. Otherwise, if a second shot is not detected and the time out timer elapsed, the loop is aborted; block 68 signals the sequence controller to revert to the previous segment and the process starts over from block 90 without progressing to the next segment of the sequence.

Referring to FIGS. 1A and 3A, bus 24 is connect to and controls the target launchers. In case of a wired arrangement, bus 24 may comprise a cable with several individual lines each controlling a relay which controls the target launcher. In a wireless system, bus 24 by be coupled to the wireless transmitter via encoder or directly via any industry standard asynchronous or synchronous serial communication interface such as UART, 1-Wire, 120, SPI, etc. the command data can be configured as required by the respective wireless transceiver’s communications protocol. The wireless receiver may comprise a decoder for controlling the target launchers via relays.

Referring to FIGS. 5A and 5B the basic user interface block 23 may comprise three light emitting diodes (LED) 25, 26 and 27 and momentary switches 28 and 29. Each of the LEDs is driven by an NPN transistor. The base of the transistor may be controlled by a digital output of the MCU. Momentary switches 28 and 29 may be mechanical, tactile or membrane switches connected to digital inputs on the MCU. Said inputs are internally pulled high and a switch when closed pulls the input low. The three LEDs 25, 26, 27 may be arranged in a triangular or other arrangement on the user interface of the present invention. The intention is to mimic the arrangement of the traditional manual switch in order to visually convey the status of the automated system to the user. LED 25 is in the upper left corner representing the High House switch, LED 26 is in the upper right corner representing the Low House switch and LED 27 is in the lower center corner representing the Doubles switch. Momentary switch 28 is marked OPTION or with a symbol representing a step back such as an arrow pointing to the left. Momentary switch 29 is marked STATION or with a symbol such as an arrow pointing to the right and ending with a vertical line. The functions of the user interface will be explained in conjunction with the Sequence Control System and with reference to FIG. 6.

Referring to FIGS. 5A-5I and 6, the Sequence Control process configured for American Skeet may comprise the steps having a few routines and sub-routines servicing the different shooting sequences in each station as shown in Table 1. Upon system start, block 121 sets the variable “Station” to an initial value of 1 representing the first station. Block 122 goes to block 123 representing a sub-routine “Station LUT” to retrieve the values for variables termed “step” and “end” for the current station from a look-up table having an index associated with the station number. At any point in time the operator (shooter) can press the Station switch 29, represented by block 131, to increase the value of the variable “Station”. As shown in blocks 132 and 133, changes to the value of “Station” are done in cyclical fashion so that the highest number associated with the index for the “Station LUT” is followed the lowest number. After any change in the variable “Station” the variables “step” and “end” are retrieved from the look-up table in block 123. LEDs 25, 26 and 27, are assigned the numbers 1, 2 and 3 respectively. Blocks 124-130 control the LEDs 25, 26 and 27. For example, in a station where the sequence comprises three segments, High house, Low house and Doubles, the variable “end” equals 3, and all three LEDs 25, 26 and 27 are turned ON. The LED(s) 25, 26 and/or 27 associated with the next segment to launch upon the shooters call “pull”, is blinking. Since the LEDs 25, 26 and 27 are arranged in the same layout as traditional skeet puller’s switch box, the LEDs 25, 26, 27 display indicates to the shooter, which switch will be pressed by the “virtual puller” when he/she calls “pull”. After loading the appropriate values to the variables “step” and “end”, block 122 resets a the segment variable termed “Sequence” to a value of 0.

Referring to FIGS. 2, 4 and 6, the voice/shot detector process described earlier with reference to is now running in a loop waiting for the shooter to call “pull”. Upon detection of the voice command “pull”, block 56 produces an instruction to launch the next target(s) into block 136 which in turn increases the value of the variable “Sequence” by the value of the variable “step”. The variable “Sequence” changes in cyclical fashion so that the value “end” is followed by the value “step” ensuring that Sequence is always a number between “step” and “end”. For example, when the system is initialized, the station is 1 and therefore “step” and “end” are 3. The initial value of “Sequence” is 0. Upon the first instruction to launch a target, Sequence=Sequence+step=1. The second instruction, Sequence=Sequence+step=2 and the third instruction, Sequence=Sequence+step=3. The next instruction will cause false (no) in decision block 137 resulting in Sequence=step=1. Once the variable “Sequence” is set, decision blocks 139 and 140 determine which launcher(s) will release. A Sequence value of 1 will release the High house launcher, a value of 2 will release the Low house launcher, and a value of 3 will release both launchers simultaneously for Doubles. The physical launching of the targets is performed via control bus 24 as discussed earlier. At any point in time, the operator (shooter) can press the Option switch 28 (FIGS. 5A-5I), represented by block 144, and cause the variable “Sequence” to be decremented by the value of the variable “step”. As shown in blocks 145-147, the changes to “Sequence” are cyclical, ensuring that “Sequence” is always
a number between “step” and “end”. Thus by pressing the Option switch, the shooter can repeat the same segment again for the purpose of the Option shot.

Continuing to refer to FIGS. 2, 4 and 6, the system provides a means for isolating the detection of a gunshot by the use of a timeout timer where the means for detecting a gunshot is enabled only during the time the target is available to be shot. In case of a shot time-out where the gunshot is not detected after the launch signal to the target launcher and before the timeout timeout TO expires, a “revert segment” instruction is issued by block 68 as a means to repeat the segment. The “revert segment” instruction has the same effect on block 145 as a shooter’s Option switch (FIG. 5A, 5B) operation. Thus as discussed earlier, if for any reason, a shot (or two shots in case of doubles) is not fired within the time-out period following the target(s) release, the variable “Sequence” is automatically set back one step so that the same segment will be activated upon the next “pull”.

Referring to FIGS. 1A-6. The present invention can be used ensure that only a preset number of shots per round is permitted. For example, the nominal number of shots per shooter in each round of skeet is 25. The present invention uses a shot counter as a means for terminating the shooting sequence based on the total number of allowed shots being taken during the sequence. For example, some gun clubs employ automatic target counters to ensure that no more than 26-30 clay pigeons are allowed per shooter. However, broken targets, gun malfunctions, etc. may require a few more targets and frequently cause conflicts between the gun club and customers. By counting the total number of shots following each target release, in each station, the system provides a means for terminating each shooting segment and can monitor the actual activity of each shooter and automatically terminate the shooting session when the allowable number of shots has been fired. The session control can be used on a per station basis and/or accumulative basis for the entire round. This feature can be used in commercial gun clubs to prevent target “pouching” while ensuring that malfunctioning of launches and equipment do not compromise the shooter’s ability to enjoy a complete round.

Referring to FIG. 7, a session control for a specific station of the present invention illustrated as a state machine process 150 for session control of a specific station is shown. It should be apparent that this process can be repeated for each station and the total number of shots accumulated for each user. At station switch 150 a transition indicates a new session is to start. Block 152 clears the variables “Shots” and “Options” and next, retrieves a value into variable MAXshot from a look-up table in block 153. The variable MAXshot equals the nominal number of shots per shooter in the current station. At any point the process can be restarted by activating the Station switch 29 (FIG. 5I) at block 151. Block 69 detects shots and then instructs block 155 to increase the value of the variable “Shots” by 1. An option shot may be requested as shown in blocks 154 and 157-159. After shooting at least one shot, the first time a shooter requests an Option shot in block 154, the variable “Options” is set to 0 and the variable Option Flag is also set to 0. Following the detection of a shot, the session status is evaluated by blocks 160-164. Decision block 160 checks if an Option has been requested. If the Option variable equals 1, once the shooter shot more shots than the value of MAXshot, the Option variable is cleared in block 163 and the session is terminated. Thus an option can be used only once. Block 161 evaluates if the nominal number of shots has been fired. If the nominal number of shots has been fired, block 164 checks if an option has been used. If the variable Option Flag is set, the option shot has already been used and the session terminates. If the option shot has not been used, the system waits for a manual input from the shooter via the Station (block 151) or Option Switch (block 154) or via any other means of user input that indicates if the session should terminate or if an option shot is needed. The state machine process 150 may be enhanced to accumulate the total number of shots taken in all stations. An extension of the state machine process 150 may include an administrator input for the number of shooters on the squad which will allow automatic change of stations once all the shooters completed their sessions in the current station.

Referencing FIG. 8, an alternate embodiment of a sequence controller 202 detecting a voice command to launch the target(s) and then detecting the following gunshot(s) to verify that targets were launched and shot, can also be used for other shotgun sports such as Sporting clays and Trap. For example, in “Five-Stand” sporting clays, up to five shooters rotate between five stations positioned a few yards from each other. Targets are launched from as many as 12 launching machines 219a, 219b, 219c, in accordance with a preset sequence. Each shooter shoots a minimum of five shots from each station. Shooters are allowed two shots at a single target. The sequence changes from station to station as well as according to the level ranking of the shooter. An example for a Five-Stand shooting sequence for each station and each level ranking in a field with eight (8) target launchers 219 is shown in table 2.

| TABLE 2 example of “Five-Stand” sporting clays shooting sequences |
|-----------------|----------------|----------------|----------------|----------------|----------------|
| Station 1 | Station 2 | Station 3 | Station 4 | Station 5 |
| Level 1 | 5 | 6 | 7 | 8 | 9 |
| 3 | 4 | 5 | 6 | 7 |
| 1 | 2 | 3 | 4 | 5 |
| Level 2 | 3 | 4 | 5 | 6 | 7 |
| 3 | 4 | 5 | 6 | 7 |
| 3 | 4 | 5 | 6 | 7 |
| Level 3 | 1 | 2 | 3 | 4 | 5 |
| 6 | 7 | 8 | 9 | 10 |

Continuing to refer to FIG. 8, an automated “Five-Stand” sporting clays controller 202 may comprise block 30 as described above with respect to FIG. 3A connected to a multiplexer 190 which has a plurality of input connections, each having a microphone 180, 182, 184, 186, 188, connected via a respective amplifier 181, 183, 185, 187, 189, connected thereto. Each of the five stations may be substantially similar to the first station described as having microphone 180 connected to pre-amplifier 181 which may be connected to multiplexer 190. The input signals from all five amplifiers 181, 183, 185, 187, 189 are fed into multiplexer 190 which may be similar to Texas Instruments SN74LV4051A-Q1). Multiplexer 190 may be controlled by MCU 70 via bus 191. The administrator’s user interface 204 connected to controller 70 which includes a means for entering 206 the number of shooters (an integer between 1 and 5) and their respective level ranking (an integer between 1 and 5). The system starts from station number 1 and shooter number 1. MCU 70 controls
multiplexer 190 to route only the input from microphone number 180, on the first station, via amplifier 181 into programmable amplifier 80 located in block 30 as per FIGS. 3A and 3B. The block 30 retrieves the first segment for station number 1 from a look-up table containing data similar to Table 2 above. The look-up table is accessed via index values based on station number and shooters ranking level. The first shooters calls "pull" and the first segment is executed by launching the target. For example, according to Table 2, for a level 2 shooter, the block 30 is connected to launchers 219a-c by control bus 224 to send a launch command from block 30 on control bus 224 to a selected one or more of launchers 206a-c, which, in the instant case, may release a target from third target launcher 219a. Once the gunshot of the first shooter is detected, the system moves to the second shooter. MCU 70 controls multiplexer 190 to route only the input from microphone 182, on the second station, via microphone amplifier 183 into programmable amplifier 80. The sequence controller reads the first segment for station number 2 in accordance with the shooters ranking level. For example if the second shooter is level 3, the system will release a target from machine number 2. After the last shooter completed the first segment, the system moves back to station number 1 and upon shooter one's "pull", executes the second segment. Continuing with the above example, the system will simultaneously release two targets from machines numbers 3 and 8. When all shooters complete their first sequence, the process is repeated with all shooter rotating to the next station. For example, shooter number 1 to station number 2 and shooter number 5 to station number 1. This process continues until the round is completed and each shooter shot a complete sequence on each station. At any station, if due to a broken target or any other failure, the shooter did not complete the minimum necessary number of shots, the system does not progress to the next shooter on the next station and the same station remains active waiting for the shooter to repeat the same segment again. The entire process is fully automatic and requires no human interference.

The first embodiment of FIGS. 1A-1D describes a variation of the invention having a signal conditioning means described as analog hardware blocks for spectral and signal level detection in conjunction with a micro-controller for controlling the operation of target launchers. The second embodiment of FIGS. 2A-2B describes the signal conditioning means described as using analog hardware blocks only for signal conditioning and a micro-controller 70 for performing all spectral and signal level analysis and for controlling the operation of target launchers. It should be apparent that a similar systems can be constructed using any combinations of analog and/or digital hardware with firmware and/or software signal processing algorithms to perform essentially the same tasks.

While there may be various methods to detect a voice command or a gunshot noise. It should be apparent that the method described herein for first detecting a voice command and launching a target(s) and then detecting the gunshot(s) of the shooter to determine the completion, or failure to complete, of a shooting segment, are the basic principals of the present invention.

A shooting sequence controller 202 comprising a block 30 having an acoustic sensor 180 connected to a signal conditioning means 181 and transmitted to multiplexer 190 controlled by control 70. The sequence block 30 further comprising a connection to multiplexer 190 a control signal output 224 connected to a plurality of target launcher 206a-c. A shooting sequence comprising a plurality of segments (Table 1) is configured in block 30 for access by an indexing pointer to execute each segment in a predetermined order. The control signal output 224 may be configured to send a target launch command to one or more of the launchers 206a-c depending on the information in the current segment indicated by the index. Each microphone 180 may be connected to an signal conditioning means such as amplifier 181 connected to multiplexer 190 to generate an audio input to block 30 in response to a detected acoustic signal. Control signal from controller 70 allows multiplexer 190 to select which microphone to monitor for an acoustic signal and likewise transmit a respective signal to block 30 when receiving the acoustic signal. The block 30 is further adapted to detect a voice command or a gunshot by ignoring ambient noise. The first target launcher 206a may be connected to the control signal output 224, whereby the sequence controller in block 30 receives a voice command signal detected by the analyzer and the block 30 thereby sends the target launch command by control bus 224 to the first target launcher 206a to launch a first target for the current shooter. Block 30 may further comprise a means for isolating the detection of a gunshot only during a target flight time when the target is in flight and available to the shooter as part of the means for ignoring noise. The block 30 may also have a means for counting a number of gunshots detected by the analyzer for counting the number of shots in the current segment and the total number of shots by the shooter in the shooting sequence. A means for terminating the segment upon receipt of the correct number of shots is used by block 30 to end segment, increment the index, and prepar block 30 to initiate the next shooting segment upon the analyzer in block 30 detecting a next voice command. A means for repeating the current segment in block 30 may be initiated if the gunshot is not detected by the end of the target flight time. A means for terminating the shooting sequence in block 30 based on a number of shots counted in the shooting sequence causes the system 202 to stop the sequence when the total number of shots allowed or paid for is detected.

The flow charts depicted herein are just examples. There may be many variations to these charts or the steps (or operations) described therein without departing from the spirit of the invention. For instance, the steps may be performed in a differing order, or steps may be added, deleted or modified. All of these variations are considered part of the claimed invention.

While the invention has been described with reference to exemplary embodiments, it should be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention. For example, certain ranges, limits, settings, and other such parameters may be modified to further implement the teachings herein. In addition, any modifications may be made to adapt a particular situation or substance to the teachings of the invention without departing from the scope thereof.

1. A shooting sequence controller comprising:
   a. a sequence controller comprising a control signal output, a signal input, the control signal output configured to send a target launch command;
   b. a microphone generating a signal in response to receiving an acoustic signal;
   c. a signal conditioning means, the signal conditioning means connected to the microphone;
an analyzer connected to the signal conditioning means, the analyzer adapted to detect a gunshot, the analyzer configured to ignore ambient noise; and
a first target launcher connected to the control signal output, whereby the sequence controller receives a voice command signal transmitted by the analyzer and sends the target launch command to the first target launcher to launch a first target.

2. The invention of claim 1 further comprising a shot counter in the sequence controller, the shot counter counting a number of gunshots detected by the analyzer.

3. The invention of claim 2, further comprising a target timeout timer in the sequence controller, the target timeout timer initiated by the activation of the target launcher, the target timeout timer in a target timing state for a target timeout period, the shot counter counting gunshots detected by the analyzer, only when the target timeout timer is in the target timing state.

4. The invention of claim 1 wherein the analyzer further comprises circuitry to analyze the spectral energy distribution of incoming audio signals.

5. The invention of claim 1, further comprising a plurality of microphones connected to the analyzer.

6. The invention of claim 5, further comprising a shooting sequence of a plurality of shooting segments in the sequence controller, an index in the sequence controller to identify a current one of the plurality of shooting segments, the current one of the plurality of shooting segments initiated by the voice command, a means for terminating the current one of the plurality of shooting segments.

7. The invention of claim 6, wherein the sequence controller further comprises a means for repeating the current one of the plurality of shooting segments if the gunshot is not detected during the target timing state.

8. The invention of claim 6, further comprising a second target launcher connected to the control signal output, the current one of the plurality of shooting segments comprising a launch command selection chosen from the group consisting of: send a launch command to the first target launcher; send a launch command to the second target launcher; or send a launch output command to both target launchers.

9. The invention of claim 1, further comprising a means for terminating the shooting sequence segment and a means for repeating the shooting sequence segment.

10. The invention of claim 1, further comprising a means for counting shots.

11. The invention of claim 6, further comprising a means for counting shots in the shooting sequence by totaling shots in each one of the plurality of shooting segments.

12. The invention of claim 11, further comprising a means for terminating the shooting sequence based on a number of shots counted in the shooting sequence.

13. A method of controlling a shooting sequence, not necessarily in the order shown, comprising:
providing a first target launcher, a microphone, an analyzer and a sequence controller, the sequence controller connected to the first target launcher, the analyzer connected to the sequence controller, the analyzer connected to the microphone, the sequence controller adapted to send a launch command to the first target launcher;
configuring the sequence controller with a shooting sequence comprising a plurality of shooting sequence segments;
providing an index in the sequence controller to identify a current one of the plurality of shooting sequence segments;
detecting a voice command at the analyzer;
sending a control signal to the sequence controller from the analyzer to indicate a detected voice command;
initiating a shooting sequence segment;
sending the launch command to the first target launcher;
detecting a gunshot at the analyzer and sending a gunshot command signal to the sequence controller; and
incrementing a gunshot counter in the sequence controller and advancing the index.

14. The invention of claim 13, further comprising, after the step of incrementing the gunshot counter, the step of: terminating the shooting sequence segment.

15. The invention of claim 14, further comprising after the step of terminating the shooting sequence segment, the step of: terminating the shooting sequence.

16. The invention of claim 13 further comprising the steps of:
starting a target timeout timer; and
repeating the current one of a plurality of shooting sequence segments by reverting to the step of detecting a voice command if no gunshot is detected.

17. The invention claim 14, further comprising the step of: signaling the next shooting sequence segment to a shooter.

18. The invention of claim 13, further comprising the step of: classifying the audio input signal into a voice command or gunshot.

19. A shooting sequence controller comprising:
a sequence controller comprising, a control signal output, a control signal input, a shooting sequence segment, the control signal output configured to send a target launch command;
a microphone;
a signal conditioning means, the signal conditioning means connected to the microphone;
an analyzer connected to the signal conditioning means, the analyzer adapted to detect a gunshot, the analyzer configured to transmit a gunshot control signal to the sequence controller, the analyzer adapted detect a voice command, the analyzer configured to transmit a voice command signal to the sequence controller, the analyzer configured to ignore ambient noise;
a first target launcher connected to the control signal output;
means for counting a number of gunshots detected by the analyzer;
means for isolating the detection of a gunshot only during a target flight time;
a shooting sequence comprising a plurality of shooting segments in a sequence controller, an index the sequence controller to identify a current one of the plurality of shooting segments, the current one of the plurality of shooting segments initiated by the voice command;
means for terminating the current one of the plurality of shooting segments:
a means for repeating the current one of the plurality of shooting segments; and
a means for terminating the shooting sequence.

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